

Analytic Method to Estimate Particle Acceleration in Flux Ropes

S. E. Guidoni, J. T. Karpen, & C. R. DeVore

NASA GSFC

The mechanism that accelerates particles to the energies required to produce the observed high-energy emission in solar flares is not well understood. Drake et al. (2006) proposed a kinetic mechanism for accelerating electrons in contracting magnetic islands formed by reconnection. In this model, particles that gyrate around magnetic field lines transit from island to island, increasing their energy by Fermi acceleration in those islands that are contracting. Based on these ideas, we present an analytic model to estimate the energy gain of particles orbiting around field lines inside a flux rope (2.5D magnetic island). We calculate the change in the velocity of the particles as the flux rope evolves in time. The method assumes a simple profile for the magnetic field of the evolving island; it can be applied to any case where flux ropes are formed. In our case, the flux-rope evolution is obtained from our recent high-resolution, compressible 2.5D MHD simulations of breakout eruptive flares. The simulations allow us to resolve in detail the generation and evolution of large-scale flux ropes as a result of sporadic and patchy reconnection in the flare current sheet. Our results show that the initial energy of particles can be increased by 2-5 times in a typical contracting island, before the island reconnects with the underlying arcade. Therefore, particles need to transit only from 3-7 islands to increase their energies by two orders of magnitude. These macroscopic regions, filled with a large number of particles, may explain the large observed rates of energetic electron production in flares. We conclude that this mechanism is a promising candidate for electron acceleration in flares, but further research is needed to extend our results to 3D flare conditions.

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